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Prognosis of the decompressive craniectomy for stroke according to preoperative computed tomography

Decompressive craniectomy for stroke

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Abstract

Aim: The aim of this study was to investigate the preoperative clinic and radiologic signs which affect the prognosis after decompressive craniectomy for stroke. Material and Method: We retrospectively analyzed the demographic and radiological images of patients who underwent decompressive craniectomy for internal carotid artery (ICA) and middle cerebral artery (MCA) strokes. Seventeen patients analyzed retrospectively between January 2012 and December 2015 at our hospital. Results: A total of 17 decompressive craniectomies were performed for supratentorial ischemic strokes: 3 (17.6%) ICA and 14 (82.4%) MCA stroke patients. There were 11 (64.7%) males and 6 (35.3%) females with a mean age of 59.35 ± 15.39 years (range 20-83 years). There were 10 (58.9%) mortalities. Seven patients were discharged home. The patients' Glasgow Coma Scale, infarct type, dominant hemisphere side, preoperative cranial tomography shift, hemorrhagic transformation, basal cistern, transcalvarial herniation were analyzed. Basal cisterns of 8 (47.1%) patients were open, of 9 (52.9%) patients were closed before decompressive craniectomy. There was a statistically significant difference between mortality rate between open cistern versus closed basal cistern (p=0.029). Discussion: In our study, open cisterns were associated with good outcomes. Larger studies should be performed in the the future.

Keywords

Basal cistern; Decompressive Craniectomy; Mortality; Stroke

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Introduction

Acute ischemic stroke is one of the destructive neurologic emergencies. Despite new therapies, about half of stroke patients have important morbidities, they need a long period of rehabilitation [1,2]. Life-threatening brain edema occurs between 2 and 5days after onset of stroke in 1-10% of supratentorial infarct patients [3]. Clinical worsening occurs within first 24 hours in 1/3 of the patients [4]. Prognosis in malign middle cerebral artery infarcts is poor, mortality is about 80% in intensive care series [5].

Wide ischemic region related to infarct with cytotoxic edema called malign infarct theoretically. This may be proportional to the volume of infarcted brain tissue and seen with increased intracranial pressure (ICP). Despite early intravenous thrombolytic treatment, the development of infarcted brain tissue in patients will continue. Successful reperfusion of ischemic and swollen vessel walls cause parenchymal blood extravasation and leads to hemorrhagic transformation. The prevalence and type of hemorrhagic transformation show the neurologic deterioration degree [6]. Decompression surgery for traumatic brain injury was for the first time described by Kocher in 1901 [7] and then was encouraged for severe acute ischemic attacks [8]. Decompressive hemicraniectomy (DCH) is a surgical treatment option for patients with malign infarct who are unresponsible to medical therapy, to prevent parenchymal brain congestion and to gain space for brain tissue recovery [3,9,10]. Trauma requires a large craniotomy, such as a bone flap. The dura on the hemisphere is expanded, and ICP is reduced by duraplasty. Anterior-medial temporal lobectomy is another surgical option to reduce the brain's pressure on vital brainstem structures when the intracranial pressure is too high [2].

As a result of three randomized controlled trials, hemicraniectomy and a decompressive surgery with duraplasty significantly reduces mortality and morbidity in patients with malignant MCA infarction [11-13]. Cranioplasty can be perfromed within 1-3 months after intracranial pressure reduction and recovery of malignant infarction area [10,14].

The aim of this study was to investigate the preoperative clinic and radiologic signs which affect the prognosis after decompressive craniectomy for stroke.

Material and Method

Patients with acute ischemic stroke who had supratentorial decompression surgery at our university hospital between January 2012 and December 2015 were analyzed retrospectively. Medical records, patients' files, and radiological images were evaluated. Hospital records kept during hospitalization period and the data obtained at the periodic routine controls were examined. Clinical characteristics, preoperative and postoperative early and late physical and neurological examination data were analyzed retrospectively. Ethical approval was obtained from our institution (31829978-050.01.04-E.1700048196 and decision number 107).

Patients with regression in Glasgow Coma Scale (GCS) or with an increase in midline shift in control computed tomography scan (CT) while undergoing medical treatment due to acute ischemic stroke in the stroke unit of our hospital, were enrolled in emergency decompression surgery.

Patients were positioned supine with a small support under the ipsilateral shoulder and the head positioned facing to the opposite side. After the sterile surgery field was covered, a large question mark incision was made, starting at 2 cm in the midline, up to the posterior parieto-occipital area and up to the posterior-inferior ear area and down to the zygoma level up to 5 mm in front of the ear. Superficial temporal artery was protected carefully to provide adequate blood flow for the skin flap. The temporal muscle was dissected and the bone was removed from the flap and hung on the frontal surface with hooks. Bone flap was removed with appropriate fronto-parietal-temporal craniectomy. The middle meningeal artery, bone surfaces, and sphenoid wing hemorrhages were stopped with bipolar cautery and bone wax. Dura opened with envelope-style, duraplasty was performed with right fascia lata, the drain was placed at the epidural space, and the bone flap was buried in the right leg. Lobectomy was performed in none of the cases. Patients with early postoperative CT were taken to the intensive care unit. Transcalvarial herniation measurements of the patients were performed as the method which was done by Flint et al. [15].

Chi-square and Mann-Whitney U tests were used for statistical calculations. P-values < 0.05 were considered statistically significant. Statistical analysis of the data was performed on a statistical package program for Statistical Package for Social Sciences for Windows 15.0 (SPSS Inc. Chicago, Ilinois, USA).

Results

Decompression surgery was performed for a total of 17 patients as follows: 3 (17.6%) with internal carotid artery (ICA) infarct and 14 (82.4%) with middle cerebral artery (MCA) infarct between years 2012 and 2015. Mean age was 59.35 ± 15.39. Eleven (64.7%) of patients were male and 6 (35.3%) were female (Table 1).

Four of operated patients were under 50 years old, 8 of them between 50-70 years old, 5 of them were above 70 years old. Preoperative infarct types of patients were evaluated by diffusion MRG sequences ,and by cranial CT according to artery feeding area. For assessment of brainstem compression and herniation in the cranial CT, the presence of compression find-

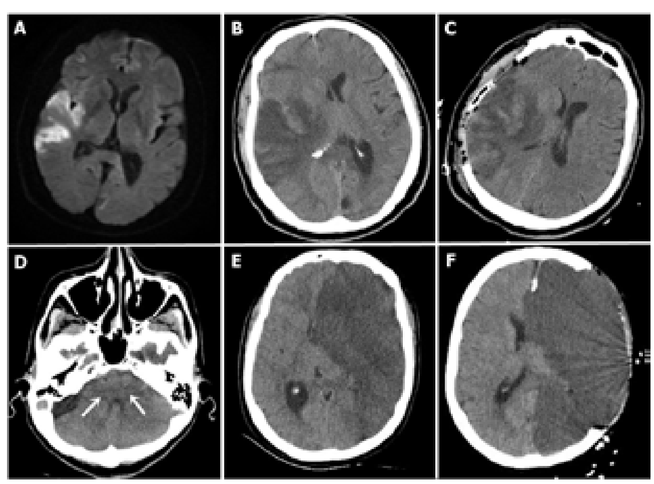

Figure 1. Patient 1; A)Preoperative diffusion weighted imaging (DWI) showed right MCA infarct, B) Preoperative CT showed midline shift, C) Postoperative Ct after decompression, Patient 2; D)Preoperative CT showed closed basal cisterns (white arrows), E) Preoperative CT showed left ICA infarctwith midline shift , F) Postoperative CT after decompression

Table 1. Demographic and clinical characteristics of 17 patients admitted to our department.

		Patient (N)	%
Gender			
	Male	11	64.7%
	Female	6	35.3%
Age			
	<50	4	23.5%
	50-70	8	47.1%
	>70	5	29.4%
Chronic Disease			
	Cardiac Disease	7	41.2%
	Hipertension	9	52.9%
	Breast Cancer	1	6.0%
	Diabetes Mellitus	6	35.3%
Glasgow Coma Scale			
	13-15	0	0
	9-12	4	23.5%
	≤8	13	76.5%
Ischaemic Stroke			
	Internal Carotid Artery	3	17.6%
	Middle Cerebral Artery	14	82.4%
Ischaemic Stroke Location			
	Left	8	47.1%
	Right	9	52.9%
Midline Shift(mm)			
	<10	3	17.6%
	≥11	14	82.4%
Preoperative Basal Cisterns			
	Open	8	47.1%
	Closed	9	52.9%
Brain Hemorrhage		10	58.9%
Surgery Time After Ischemia (h)			
	0-24	11	64.7%
	>24	6	35.3%
Temporal Bone Craniectomy		15	88.2%
Postoperative Transcalvarial Herniation(mm)			
	<20	10	58.9%
	≥20	1	5.9%
Unknown		6	35.3%
Postoperative Brain Shift (mm)			
	<10	7	41.2%
	≥10	4	23.5%
Unknown		6	35.3%
Mortality		10	58.9%

ings in basal cisterns (Quadrigeminal, ambient, perimesencephalic) was evaluated. Before the decompressive craniectomy, eight of the basal cisterns (47.1%) were open, and nine (52.9%) were closed. At the same time, hemorrhagic field was also evaluated in cranial CT (Figure 1). In the surgical procedure applied to the patients, temporal craniectomy was performed in 15 patients including the sphenoid wing and temporal pole. Two patients were decided not to undergo extensive craniectomy involving the sphenoid wing and temporal pole as a result of preoperative observation and the operation was completed by frontoparietotemporal craniectomy.

Table 2. Comparison of preoperative radiological signs of patients with stroke.

		Basal Cisterns Open (N=8)/%	Basal Cisterns Closed (N=9)/%
Gender			
	Male	2(11.8%)	9(52.9%)
	Female	6(35.3%)	0
Age			
	<50	2(11.8%)	2(11.8%)
	50-70	5(29.4%)	3(17.6%)
	>70	1(5.9%)	4(23.5%)
Chronic Disease			
	Cardiac disease	3(17.6%)	4(23.5%)
	Hipertension	5(29.4%)	2(11.8%)
	Breast Cancer	0	1(5.9%)
	Diabetes mellitus	4(23.5%)	2(11.8%)
Glasgow Coma Scale			
	13-15	0	0
	9-12	4(23.5%)	0
	≤8	3(17.6%)	10(58.9%)
Ischaemic Stroke			
	Internal Carotid Artery	1(5.9%)	2(11.8%)
	Middle Cerebral Artery	7(41.2%)	7(41.2%)
Ischaemic Stroke Location			
	Left	2(11.8%)	6(35.3%)
	Right	5(29.4%)	4(23.5%)
Midline Shift(mm)			
	<10	3(17.6%)	0
	≥11	5(29.4%)	9(52.9%)
Brain Hemorrhage		7(41.2%)	3(17.6%)
Surgery Time After Ischemia (h)			
	0-24	5(29.4%)	6(35.3%)
	>24	3(17.6%)	3(17.6%)
Temporal Bone Craniectomy		7(41.2%)	8(47.1%)
Postoperative Transcalvarian Herniation(mm)			
	<20	8(47.1%)	2(11.8%)
	≥20	0(0.0%)	7(41.2%)
Postoperative Brain Shift (mm)			
	<10	7(41.2%)	2(11.8%)
	≥10	1(5.9%)	7(41.2%)
Mortality		2(11.8%)	8(47.1%)

One of the operated patients had undergone ventriculoperitoneal shunt due to acute hydrocephaly at the postoperative 2nd month, and cranioplasty operation had performed in 1 patient at the postoperative 6th month. Other patients did not accept cranioplasty operation. No significant value has been found between GCS, infarct type, hemisphere side, pre-post- operative midline shift, hemorrhagic transformation, transcalvarial herniation, operation time, modified ranking scale and mortality. However, it was statistically significant between basal cistern closed and mortality (p = 0,029)(Table 2).

Discussion

Duraplasty with decompressive hemicraniectomy supports edema enlargement to the outside of the neurocranium and thereby, prevents lethal internal displacement and subsequent herniation of brain tissue. Decompressive hemicraniectomy is

particularly useful in patients with malignant middle cerebral artery infarction [13].
Analysis of three prospective studies (DECIMAL, DESTINY I, HAMLET) showed that decompressive craniectomy significantly reduced mortality by about 50% in patients under 60 years of age [16]. Uhl et al. in the study of 188 patients under 50 years of age, evaluated decompression surgery as promising [17]. Juttler et al. in their study of 112 middle cerebral artery infarct patients over 60 years of age, showed significantly increased survival rates when decompressive craniectomy was performed within the first 48 hours (early surgery) [13]. Vahedi et al. in a study of 93 patients older than 50 years old, had 80% mortality rate [3]. In our study, the mean age was 59.35 ± 15.39 years (range 20-83). Patients were separated as follows: under 50 years, 50-70 years and over 70 years of age, but mortality rates were not significantly different.
Palival et al. showed that in 75 patients with moderate cerebral artery infarction who were treated by decompressive craniectomy, early surgery within 48 hours increased survival rates regardless of age [1]. Both DECIMAL and DESTINY trials showed that for patients who were treated by surgery within 48 hours after symptoms start, early and long-term mortality rates were decreased and neurologic results improved [18,19]. In the study by Foerch et al. of 36 cases, time of decompressive craniectomy had no effect on mortality and functional outcomes [20]. In our study, there were no significant differences between the first 24 hours, 24-48 hours, 48-72 hours, and 72 hours after the onset of symptoms and surgery time and there were no significant differences between patients' ages and survival rates. Both in the study by Foerch et al. [20] and our study, as well as the small number of patients is thought to result in the absence of an effect on the outcome of the surgical timing.
Recently, 4 points in modified ranking scale has been considered favorable for evaluating survival of patients, but in the last period modified Rankin scale (mRS) ≤ 3 was considered more favorable [1]. In our study, mRS was 4 in 2 of 6 survivors, 5 was in 3, and 3 was in 1 patient.
In the studies related to patients who underwent decompression surgery due to MCA infarction, right MCA was more frequent than left side [1,13,18,21]. Paliwal et al. stated that right MCA infarction rate was 70% [1]. In our study, righ MCA infarction rate was 64.3%.
The expected amount of postoperative brain herniation varies according to the patients. The maximum extracranial herniation was reported by Fletcher et al. [22] and Flint et al. [15] as 20-40 mm. The difference between measurements occurs due to many factors. Both studies are used to measure herniation in traumatic brain-damaged patients, so the amount of herniation is high. In our study, transcalvarial herniation values were between 0-23 mm. There was no significant difference between the amount of transcalvarial herniation and mortality in our study. A study of Kouvarellis et al. with 141 pediatric cases with traumatic brain injury, resulted in an increase in intracranial pressure in patients with close basal cistern and lower survival rates [23]. Nourallah et al. revealed that evaluation of basal cisterns in brain CT was directly related to brain stem pressure independent of other parameters (such as age, midline sp shift) in assessing premorbid findings in traumatic brain injury [24]. Uncal, parahippocampal, and central transtentorial herniation reflect the pressure effects of a wider range of compartments, and basal cistern pressure can be detected earlier, radiologically [24]. In the literature, radiological signs have been tried to be defined as pre-herniation findings indicative of urgent decompressive craniectomy to help to diagnos and treat brain stem damage that will be developed secondary to malignant MCA infarction. In some studies, a larger infarct region more than 50% of the MCA irrigation area in cranial CT or larger than 145 cm^3 infarct area showed urgent need for decompressive craniectomy. [3,18,21]. Significant results were obtained in our study between the appearance of open baseline cisterns in cranial CT and survival rates of the patients (p = 0.029). The results of our study showed that preoperative evaluation of basal cisterns on cranial CT may be useful in predicting prognosis, and patients with preoperative open baseline cisterns on cranial CT may have better prognosis..
The limiting factor in our study is the small number of patients. In our study, although there was no significant difference between decompression timing and mortality, early decompression surgery was found to have better results in many studies [1,3,13].

Scientific Responsibility Statement
The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement
All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest
None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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